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Fire extinguishing rover

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ABSTRACT

In 20th century Robotics and Artificial Intelligence (AI) are the most require technology in our society. Human interruption has became less and robots are being used for various purposes. Fire casualty keeps on going frequently which causes trouble to human life, property and make difficulties for the fire fighters to save life. So, Our aim is to make a fire fighting robot which have ability to detect fire and works accordingly on it. This robot has a two main feature automatic and Manual. In Automatic mode, our robot first detect obstacle in a definite path. After detecting a obstacle it stops at a certain distance from the obstacle. The ultrasonic sensor moves it head from left to right with the help of servo motor to detect whether there is any obstacle or not. Then it changes its direction and moves forward. When there is any fire comes near the robot, it detects the fire by the flame sensor and sends a signal to the relay module such that it turn ON the water pump to extinguish the water. In Manual mode, the control of the robot is in the hand of the controller. We will use ESP32 CAM WIFI MODULE BLUETOOTH with OV2640CAMERA module 2MP to control our robot manually. At the moment of fire detection the controller sends a signal to the water pump to extinguish the fire.

Keywords: fire extinguishing rover, autonomous firefighting, sensing and perception systems, fire detection, fire suppression, autonomous navigation

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1. INTRODUCTION

Fires are a global concern, causing substantial loss of life and property. The complexity and hazardous nature of certain fire scenarios, such as wildfires, industrial incidents, and urban fires, necessitate the development of innovative firefighting solutions. This research proposes a fire extinguishing rover, a robotic system capable of autonomously navigating diverse terrains and executing firefighting operations efficiently.

The 'size and weight' and 'cost and execution' of firefighting robots are gives as of now. Presently trials are given to sort out a firefighting robot with self-satisfied shirking and recognizing the fire and smothering the fire. Security and Firefighting influenced robot which is used in the UK is remarkably low in cost and have otherworldly of seeing fire and smothering them.

The system can have organized a canny Multi-sensor-based security that contains a firefighting bot in our regular day to day existence. For the novel fire around the environmental factors utilizing picture preparing and gadget controlling calculations to recognizing fire quickly and precisely. Right now, of security on street and railroads burrows considered to more hazard associated with flames, this automated framework can be introduced on the current passages without requiring huge adjustments of the current foundations.

At the moment of fire detection, a signal is sent to the water pump to extinguish the fire. Additionally, the Fire Extinguishing Rover is equipped with intelligent software and machine learning algorithms that enable it to autonomously navigate the fire scene, detect hotspots, and identify potential hazards.

This autonomous capability reduces the risk to human firefighters and allows them to focus on other critical tasks, such as evacuating civilians or coordinating rescue operations [1-4].

2. HARDWARE IMPLEMENTATIONS

2. 1. Design

The design of a fire extinguishing rover requires careful consideration of various factors, including mobility, sensing capabilities, fire detection mechanisms, and fire suppression techniques [5].

2. 1. 1. Mobility

The rover should be designed to navigate various terrains efficiently, including rough surfaces, debris, and obstacles commonly found in fire-affected areas.

2. 1. 2. Remote Operation

Enable remote operation of the rover to ensure the safety of the operator and allow flexibility in controlling the firefighting proces [2]. Incorporate advanced communication systems to maintain a reliable connection between the operator and the rover, allowing for real-time monitoring and control [3].

And various other methods are needed to design it in a more flexible and durable manner.

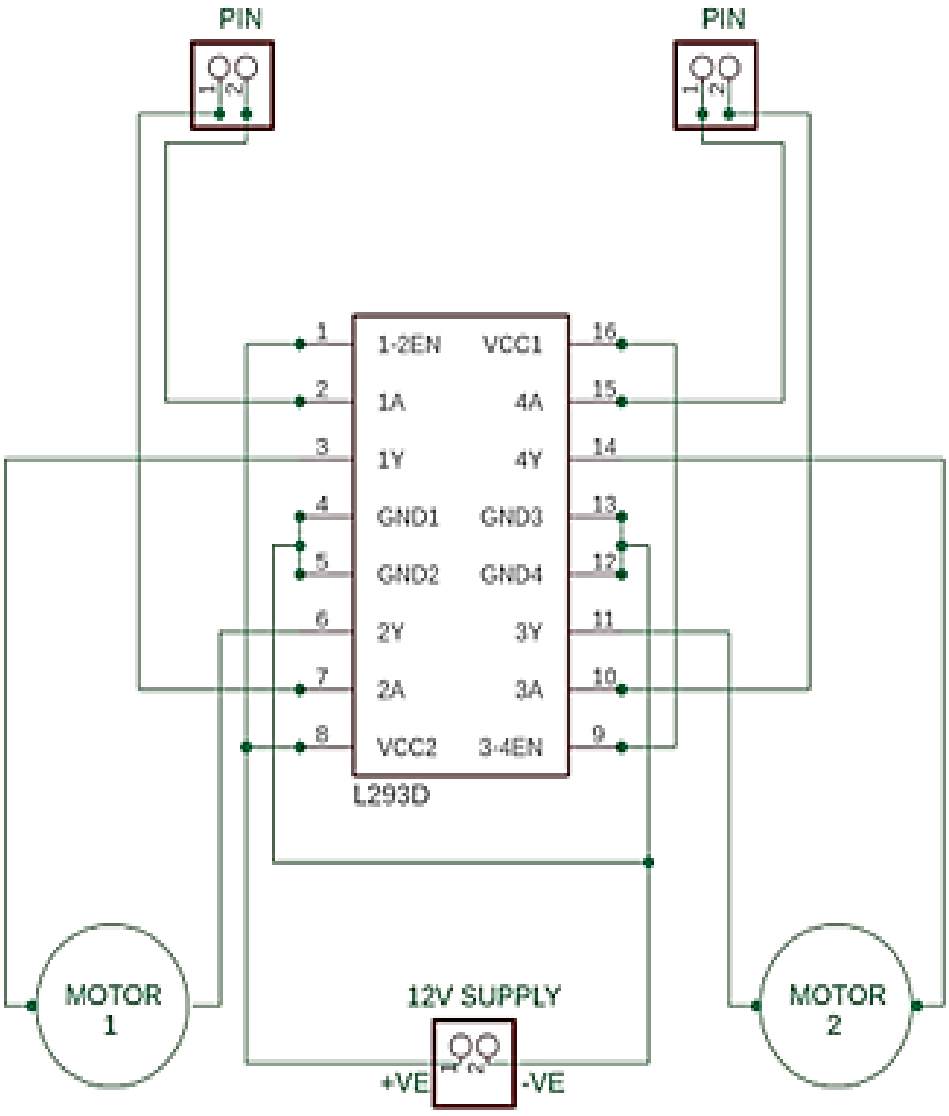

Figure 1. Circuit diagram of Motor driver

2. 1. 3. Sensing and Perception Systems

Sensing and perception systems are crucial components of a fire extinguishing rover, as they enable the robot to detect and understand its environment accurately. Different types of sensors used are as follows:

A. Fire Detection Sensors

Fire detection sensors are capable of identifying the presence and location of fires[5]. These sensors can include infrared (IR) or thermal cameras, smoke detectors, or flame sensors. They should be sensitive enough to detect fires even in challenging conditions, such as heavy smoke or low visibility.

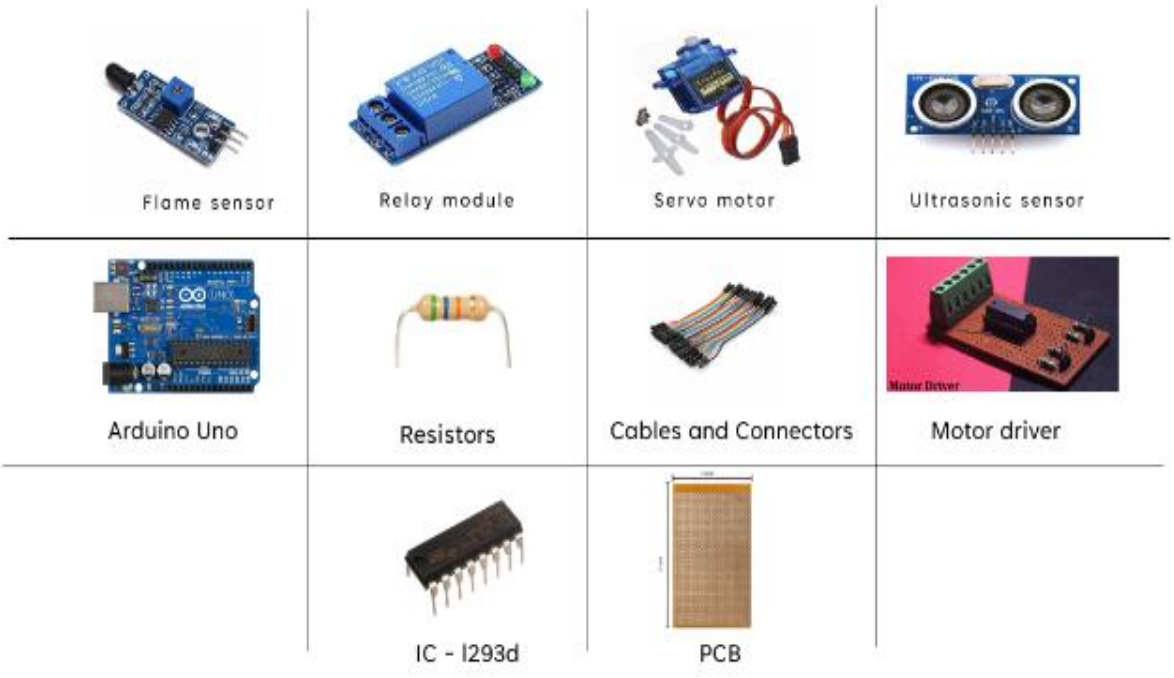

Figure 2. Components of main part of rover

Figure 3. Components of remote operation

B. Obstacle Detection Sensors

Obstacle detection sensors, such as proximity sensors, ultrasonic sensors are utilized to identify obstacles in the rover's path[5]. This ensures safe navigation and helps the rover avoid collisions with objects or terrain.

C. GPS and Localization

GPS (Global Positioning System) and localization systems are to be integrated accurately determine the rover's position and track its movements. This information can be vital for navigation, coordinating multiple rovers, and mapping fire-affected areas.

2. 1. 4. Human-Computer Interaction

Design intuitive user interfaces and displays to present the sensor data and provide real-time information to the operator [6, 7]. This facilitates the effective communication between the rover and human firefighters, allowing them to work collaboratively.

3. FIRE DETECTION AND CLASSIFICATION

The rover's fire detection system combines thermal imaging, gas sensors, and machine learning algorithms to identify and classify fires accurately.

Fire Detection Sensors- This integrates the sensors capable of detecting the presence of fire. These sensors can include thermal cameras, infrared (IR) sensors, or flame detectors. The sensors should be sensitive to the heat signatures or specific wavelengths emitted by fire, enabling accurate detection even in challenging environments or low-visibility conditions.

Real-time Monitoring- It ensures the fire detection system provides real-time monitoring of the environment. The sensor data should be processed promptly to detect fires as early as possible and enable rapid response. Real-time monitoring allows the rover to quickly assess the situation and initiate firefighting actions promptly [8-10].

Machine Learning and AI- It utilizes machine learning and AI techniques to improve fire detection and classification accuracy [4]. Train the algorithms using a diverse datasets of fire scenarios to enhance their ability to recognize and classify different types of fires. Continuous learning and adaptation can improve the rover's performance over time.

Smoke Detection:- Smoke detectors are incorporated to complement fire detection sensors. Smoke detectors can provide additional cues for fire detection and contribute to a more comprehensive understanding of the fire situation [11]. The combination of fire and smoke detection enhances the rover's ability to assess the severity and spread of the fire.

3. 1. Fire Suppression Mechanisms

The fire extinguishing rover is equipped with advanced fire suppression mechanisms. These may include high-pressure water cannons, foam dispensers, or chemical agents, depending on the specific fire scenario. The rover's intelligent algorithms determine the most effective suppression method based on the fire's characteristics, ensuring efficient firefighting operations.

Water-based Systems- These systems include a water-based fire suppression system as a primary extinguishing mechanism. This can involve a water tank, pumps, and nozzles to spray

water onto the fire. Ensure an adequate water supply for prolonged firefighting operations, and incorporate mechanisms for water pressure control and efficient water distribution.

3. 2. Communication and Coordination

The fire extinguishing rover is designed to communicate and coordinate with other firefighting assets, such as human firefighters, aerial drones, and command centers. Real-time data sharing and collaborative decision-making enhance the overall effectiveness of firefighting efforts and enable a more comprehensive response to fire incidents [12-16].

Wireless Communication- It establishes a reliable wireless communication system between the rover and the control centre or human operators[12]. This can involve technologies such as Wi-Fi, cellular networks. Ensure sufficient range and bandwidth for seamless communication even in remote or obstructed areas [11].

Remote Operation and Control- It designs the rover to be remotely operated and controlled from a safe location [17, 18]. It provides human operators with intuitive interfaces and control systems that allow them to monitor the rover's actions, adjust settings, and initiate firefighting operations as necessary.

Alarm and Alert Systems:- Implement alarm and alert systems are used to notify human operators and other personnel of critical events or emergencies [19]. This can include audio alarms, visual indicators, or text messages to ensure prompt responses and coordination during firefighting operations [20].

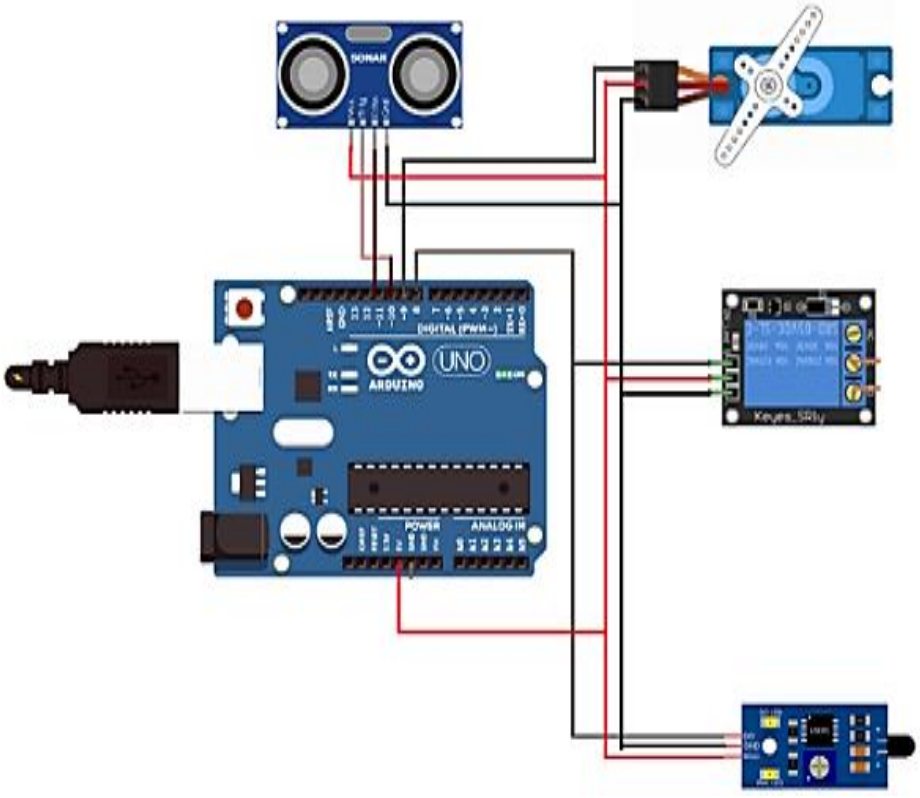

Figure 4. Connection of the sensors

4. SOFTWARE IMPLEMENTATIONS

It consists of various programming languages like Arduino ide.

4. 1. In the setup() function

- Motor control pins (in1, in2, in3, in4) are configured as outputs.
- Motors are turned off.
- Serial communication is initialized at a baud rate of 9600.
- Servo motor is attached to pin 9.
- Flame sensor pin (FLAME Sensor) is configured as an input.

```
  MoveRight();
  delay(500);
  servo1.write(90);

}
  else
{
  MoveLeft();
  delay(500);
  servo1.write(90);

}
}
else
{
  MoveForward();
  servo1.write(90);
}
}
```

4. 2. In the loop() function

- The ultrasonic sensor measures the distance (distance) using the UltrasonicDistance() function.
- If the distance is less than 50 units, the robot stops and performs obstacle avoidance:
- The robot stops for 500 milliseconds (delay(500)).
- The robot looks left and measures the distance (distanceL) using the LookLeft() function after a delay of 1 second.
- The robot looks right and measures the distance (distanceR) using the LookRight() function after a delay of 1 second.
- If the left distance (distanceL) is less than 60 units, the robot turns right (MoveRight()) and waits for 500 milliseconds (delay(500)). Then, the servo motor returns to the center position (servo1.write(90)).
- Otherwise, the robot turns left (MoveLeft()) and waits for 500 milliseconds (delay(500)). Then, the servo motor returns to the center position (servo1.write(90)).

- If the distance is greater than or equal to 50 units, the robot moves forward (MoveForward()) and the servo motor returns to the center position (servo1.write(90)).

```
void setup() {
  // Set all the motor control pins to outputs
  pinMode(in1, OUTPUT);
  pinMode(in2, OUTPUT);
  pinMode(in3, OUTPUT);
  pinMode(in4, OUTPUT);
  // Turn off motors - Initial state
  digitalWrite(in1, LOW);
  digitalWrite(in2, LOW);
  digitalWrite(in3, LOW);
  digitalWrite(in4, LOW);
  Serial.begin(9600);
  delay(100);
  //Attach Pin 9 For Signal Output
  servo1.attach(servoPin);
  pinMode(FLAMESensor, INPUT);
}
```

4. 3. Motor control functions

```
void loop()
{
  int distanceL;
  int distanceR;
  servo1.write(90);
  int distance=UltrasonicDistance();


if(distance<50)
{
  StopRunning();
  delay(500);
  distanceL=LookLeft();
  delay(1000);
  distanceR=LookRight();
  if(distanceL<60)
{
```

- MoveForward(): Moves the robot forward.
- MoveBackward(): Moves the robot backward.
- MoveRight(): Turns the robot to the right.
- MoveLeft(): Turns the robot to the left.
- StopRunning(): Stops the robot and performs a short backward movement before stopping.

```
// This function lets you control spinning direction of motors
void MoveForward() // TO move Forward
{
  digitalWrite(in1, HIGH);
  digitalWrite(in2, LOW);
  digitalWrite(in3, HIGH);
  digitalWrite(in4, LOW);
  delay(500);
}
void MoveBackward() // TO Move Backward
{
  digitalWrite(in1, LOW);
  digitalWrite(in2, HIGH);
  digitalWrite(in3, LOW);
  digitalWrite(in4, HIGH);
}
void MoveRight() //To Move Right
{
  digitalWrite(in1, HIGH);
  digitalWrite(in2, LOW);
  digitalWrite(in3, LOW);
  digitalWrite(in4, HIGH);
}
```

4. 4. Sensor functions

```
void MoveLeft() //To Move Left
{
  digitalWrite(in1, LOW);
  digitalWrite(in2, HIGH);
  digitalWrite(in3, HIGH);
  digitalWrite(in4, LOW);
}
void StopRunning() // To Stop Running
{
  digitalWrite(in1, LOW);
  digitalWrite(in2, LOW);
  digitalWrite(in3, LOW);
  digitalWrite(in4, LOW);
  delay(100);
  MoveBackward();
  delay(100);
  digitalWrite(in1, LOW);
  digitalWrite(in2, LOW);
  digitalWrite(in3, LOW);
  digitalWrite(in4, LOW);
  }
```

- UltrasonicDistance(): Measures the distance using the ultrasonic sensor and returns the distance in centimeters.

- LookLeft(): Turns the servo motor to the left, measures the distance using the ultrasonic sensor, and returns the distance.
- LookRight(): Turns the servo motor to the right, measures the distance using the ultrasonic sensor, and returns the distance.

```
int UltrasonicDistance()
{
  delay(50);
  unsigned int uS = sonar.ping();
  int cm = sonar.convert_cm(uS);
  if(cm==0)
  {
    cm = 250;
  }
  return cm;
}

 int LookLeft()
   {
   servo1.write(180);// look left
   delay(500);
   int distance=UltrasonicDistance();
   servo1.write(180);
   delay(100);
   return distance;
   }
 int LookRight()
   {
   servo1.write(0);//look left
   int distance=UltrasonicDistance();
   servo1.write(0);
   delay(100);
   return distance;
   }
```

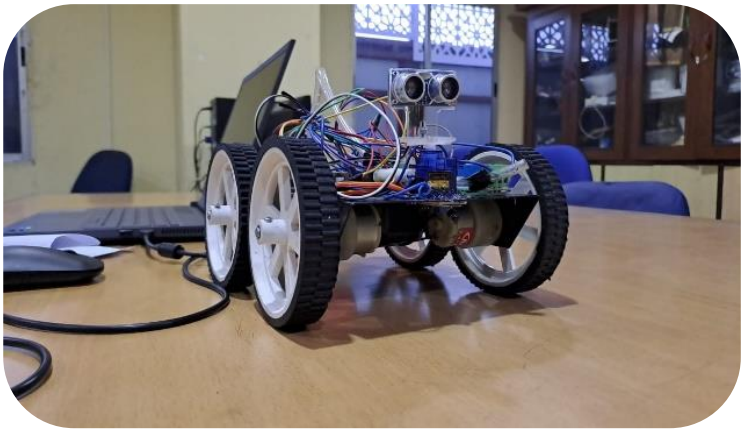

Figure 5. Fire extinguisher

5. FIRE EXTINGUISHING TECHNIQUE

SG90 servomotor which is placed at the rear side of a rover has a high torque of 11 kg/cm when operated at 6V supply [16]. This Servo-motor is thus used to pull the lever of an extinguisher which needs a significantly large torque for its operation [19]. It helps to mover at any types of road condition [21].

6. RESULTS AND DISCUSSION

After the completion of the robot operation and the establishment of a wireless connection between the robot and the android app, a practical test was carried out which shows that it can move in any direction at the situation manually and automatically so that is can go to any situation of fire [14].

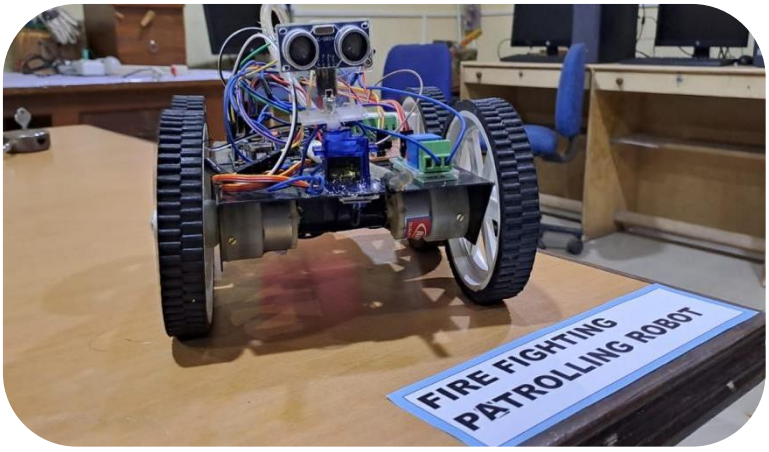

Figure 6. Fire fighting patrolling robot

7. CONCLUSION

The fire extinguishing rover offers a promising solution to enhance the effectiveness and safety of firefighting operations in challenging environments [16]. By combining advanced sensing technologies, autonomous navigation, and intelligent fire suppression mechanisms, the rover can autonomously detect and suppress fires while reducing human exposure to hazardous conditions.[29] Further research and development in this area will contribute to more efficient and proactive fire management strategies in the future[17]. Furthermore, the integration of advanced sensors, cameras, and communication systems provides real-time situational awareness, enabling operators and other personnel to assess the fire scene, monitor the effectiveness of firefighting strategies, and adjust tactics as needed [19]. The rover's versatility in handling different fire types and its continuous operation and maintenance considerations contribute to its overall effectiveness and reliability [22]. Overall, a well-designed fire extinguishing rover has the potential to revolutionize firefighting operations by enhancing

safety, response times, and overall effectiveness, ultimately minimizing fire damage and protecting lives and property [23].

8. FUTURE PERSPECTIVE

The Fire Extinguishing Rover is an autonomous firefighting marvel, designed to detect and extinguish fires in hazardous environments Equipped with cutting-edge sensors and AI, it navigates through smoke, deploys fire-suppressing agents, and safeguards lives and property.

A global game-changer, reducing firefighter risks and combating fires where humans cannot venture. Its legacy sparks innovation in robotics and fire safety, creating a safer world for all.Widely deployed in disaster zones, it mitigates wildfires, industrial accidents, and natural calamities. Continuous upgrades improve its adaptability to diverse terrains [24-27].

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